ceramic oxide powder particles is induced, while the ceramic sol acts as a reaction medium on the surfaces of the ceramic oxide particles.

Also the present invention features a piezoelectric/electrostrictive film element produced by a method comprising the steps of: preparing a solution or a dispersed mixture containing constituent ceramic elements by dissolving or dispersing the raw material of constituent ceramic elements in a solvent or dispersion medium; preparing a mixed solution by adding citric acid into the solution or the dispersed mixture in which the constituent ceramic elements are dissolved or dispersed; getting ultrafine ceramic oxide powder of particle size less than 1 $\mu$m with uniform particle diameter size distribution by forming ceramic oxide without scattering over, by a nonexplosive oxidative-reductive combustion reaction by thermally treating the mixed solution at 100-500°C; preparing a suspension by dispersing the ultrafine ceramic oxide powder in an organic dispersant; preparing a ceramic sol solution by dissolving constituent ceramic elements of the same or similar constituent as the ultrafine ceramic oxide powder in water or an organic solvent;l dispersing by mixing with the ceramic sol solution the suspension in which the ultrafine ceramic oxide powder is dispersed; forming a piezoelectric/electrostrictive film element by submerging a substrate into the suspension in which the ultrafine ceramic oxide powder and the ceramic sol solution are mixed and then performing electrophoretic deposition; and thermally treating the piezoelectric/electrostrictive film element at 100-600°C, so that the solvent is removed by the thermal treatment and bonding among the ultrafine ceramic oxide powder particles is induced, while the ceramic sol acts as a reaction medium on the surfaces of the ceramic oxide particles.

## BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a flow diagram for method for producing ultrafine ceramic oxide powder used in the present invention.

Figure 2 is a flow diagram of a process for forming a piezoelectric/electrostrictive film element using the conventional electrophoretic deposition.

Figure 3 is a flow diagram of a method for forming a piezoelectric/electrostrictive film element using electrophoretic deposition at low temperature according to the present invention.

## DETAILED DESCRIPTION

The present invention will be explained in detail.

First, a method for producing an ultrafine ceramic oxide powder used as a raw material in a piezoelectric/electrostrictive film element produced according to the present invention as in the flow diagram of Figure 1 will be explained.

An ultrafine ceramic oxide powder manufacturing method of the present invention comprises the steps of: sufficiently dissolving or uniformly dispersing the raw material of constituent ceramic elements in a solvent or dispersant to make a solution or a dispersion mixture containing the constituent ceramic elements; adding, into the solution or the dispersion mixture containing the constituent ceramic elements, citric acid in no less than the required amount to give rise to an oxidative-reductive combustion reaction with a anion of the ceramic constituent ceramic element so as to make a mixed solution; and thermally treating the mixed liquid at 100-500°C. But it may additionally further comprises a step of conducting additional thermal treatment at 700-900°C to increase crystallinity.

As for the raw material containing the constituent ceramic elements, use is made of an oxide, carbonate, nitrate etc. of constituent ceramic element, its salt with organics or inorganics, or a constituent ceramic element complex.

As for the constituent ceramic element, it is preferable to use a piezoelectric/electrostrictive ceramic element comprising lead (Pb) and titanium (Ti) as basic constituent elements.

Especially as to the constituent ceramic element, it is preferable to use that composed of elements including lead (Pb), zirconium (Zr) and titanium (Ti), or lead (Pb), zirconium (Zr), titanium (Ti)/lead (Pb), magnesium (Mg), niobium (Nb).

As for the solvent or the dispersant to dissolve or disperse the raw material of the constituent ceramic elements, one or more are selected from among water and organic solvents that can dissolve or disperse the raw material containing the constituent ceramic elements. As for the organic solvents, mainly acetic acid, dimethyl formamide, methoxyethanol, alcohols, or glycols are used.

As for the combustion aid, citric acid is used, which is an organic compound that can give rise to a combustion reaction. In the conventional method, citric acid has been used, not as a combustion aid, but as a complexing agent in order to give reaction uniformity; and it has been used in processes such as the Pechnini process, where a speed-controlled combustion reaction can be induced using citric acid's flammability and complex formation effect.

A mixture is made by adding citric acid into a solution or a dispersed mixture where constituent ceramic elements are dissolved or dispersed. The quantity of the citric acid added shall not be less than the necessary amount to give rise to an oxidative-reductive combustion reaction with the anion of the constituent ceramic element. Reaction speed can be controlled by the quantity of citric acid added.

The mixture made by the addition of the citric acid is thermally treated at 100-500°C. Though the crystallinity of the ceramic phase increases with the temperature for the thermal treatment, the citric acid combustion reaction may start enough if the temperature for the thermal treatment is over 100°C. Although the reaction can arise even if the temperature for the thermal treatment is above 500°C, thermally treating above that temperature is meaningless when compared with the conventional method.